BIO-DYNAMICS

A periodical furthering soil conservation and increased fertility in order to improve nutrition and health.

WINTER - SPRING 1953

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VOL. XI NOS. 1 & 2

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BIO-DYNAMIC FARMING AND GARDENING ASSOCIATION, INC.

R. D. 1, CHESTER, NEW YORK

"Bio-Dynamics" Trade Mark Registered - Price 40c a copy; $1.50 a year

COMPOSTING AGAIN — SMALL AND LARGE

EHRENFRIED E. PFEIFFER

Composting of organic wastes on the farm or in the garden is an old art, probably as old as man's tilling of the soil. Old-fashioned composting has been practiced right up to our own times. But it remained for the modern agriculturist, the farmer who has to work under the pressure of time, wage scales and scientific fertilizing, to find out that these methods were too expensive. Hence he tried to replace composting in one way or another. The good gardener never entirely lost sight of it.

The scientific age with its teachings of mineral deficiencies and fertilizers, the so-called "Liebig-Age," looked down on composting for a while, only to discover in time that without organic matter in the soil, minerals alone will not solve the problems. So composting has become a new skill to be learned. And at this time, under the scrutiny of science, progress has been made in many regards, and we are now on the threshold of a new age—The Organic Age—when composting becomes a science —and an industry.

The rules of small composting in the home garden or on the farm have been so well publicized in recent years that we need only mention that the building of a good pile is a matter of skill. Practice has also shown that when scientific procedures are used, the pile can rot down to a fine humus in half, or less, the time that was needed when following the old well-trodden path.

The purpose is in any case to get humus and to incorporate this humus into the soil. The points of view about humus and compost have of necessity changed a bit, and are still changing.

Humus, as it derives from decaying plants, refuse, and manure, is not fertilizer in the sense the word is used nowadays. One argument from the orthodox "plant food" and fertilizer camp is that there is not enough compost-humus available to satisfy the needs of a modern, intensified agriculture. This is, regrettably, true.

It is generally acknowledged that a farmer should use 10 tons of farmyard manure per acre, in a proper crop rotation, in order to maintain his land in a good state of fertility. There is not enough manure available to carry out this rule of experience, especially in areas where there is no livestock and where the tractor has replaced the horse. The small farmer of the

under-developed areas of the world, who has to make a living from a few acres, has it easier in this regard than the big operator who farms hundreds or even thousands of acres intensively.

Evidently humus helps to "hold the soil." It absorbs and retains moisture, so that humus soils are more resistant to drought and also can take better care of excessive moisture. Humus soils are of crumbly structure due to the microlife which develops in them. They hold the mineral supplies in an available state, ready for plant growth. Virgin soils used to have 4 to 6% organic matter; today the U. S. average for agricultural soils is 1.5% organic matter. There are many soils, especially on truck farms, below this average which, by the way, is already *the critical level*, indicating a breakdown of the soil. Good soils have better than two percent organic matter, but these become rarer and rarer.

Composting is not the job of a privileged class of enthusiasts and organic gardeners, called by some people "organic faddists," but rather it is a *must* unless we are to lose out with our soils, adding complete depletion to erosion.

At present the use of organic wastes in the form of compost is looked upon as a soil conditioner and as food for the microorganisms in the soil, rather than as fertilizer. How important it is to "feed" the soil may be realized if it is known that an acre of good soil contains, to a depth of about 7", up to 1,500 pounds of soil bacteria and 750 pounds of fungi and tiny animal organisms.

In order to simplify matters, and to economize, the suggestion of green manuring has been made, also the use of so-called sheet composting. No doubt green manuring adds a considerable amount of bulk organic materials, ranging between 5-20 tons per acre. Heavy, wet soils, however, do not take well to plowed-under green manures; and all soils are tied down by them for a considerable length of time. In fact observation has shown that green manuring consumes microlife and temporary nitrogen deficiencies are caused, lasting until the green matter is decomposed. Sheet composting means that the crude, sour wastes like garbage are spread over the fields and turned under as they are. This also ties down soil life and nitrogen for a while, and creates different structural conditions until the wastes are decomposed. Should there be diseases, fungi, insect eggs, larvae in the waste, there is no better way to spread them than by sheet composting. So we come back to composting as

a must: applying decomposed, humified matter which is readily available.

Industrial composting methods have developed in the past decades along various lines, using garbage, stockyard manure, industrial wastes. Some of these methods were successful, others not. Most proved to be too expensive due to costly machinery and handling, i.e. labor, involved. Almost every country has had some experience with one or another process. If one starts to introduce a new process, as this writer did, one is confronted with history and is told: Yes, we see it is a good thing to compost wastes, we need organic matter for our soils, but this man and that man and that other man have all tried it and found it too expensive and had to give up again. Some have developed a product which sells for a premium—it would be more accurate to say, sells as a "luxury item"—considering the amount of money a farmer can afford to spend per acre by way of organic fertilizer.

In order to solve the problem of the composting of industrial and urban waste, two questions have to be answered: (a) Can it be done, taking care of a large volume of material per day? (b) Can it be done economically? Many a process which looks good when 5 or 10 tons a day are produced becomes too troublesome and expensive when 50 to 100 tons a day have to be treated.

It is not the purpose of this article to give a critical analysis of composting processes of the past or present. A few names, which have been, or are, in the public eye, are mentioned by way of historical record. There is for instance Sir Albert Howard's Indore Method, mixing and piling source materials. The fermentation is left more or less to nature and chance, though the conditions of an "ideal" compost pile have been very well developed. Frequent turning of the pile produces the best effect. This, alas, reduces the usefulness of the method for large scale operations.

From France and Italy there have come methods which make use of bins, aerated bins, fermentation cells. When tried in this country, they proved to be cumbersome, and not sufficiently up to economic standards, and so had to be given up. Verdier's and Baccari's processes may be mentioned at this point. There is quite an extensive patent literature on digesters in which the materials to be composted are mechanically transported, and pass through a digester which maintains most favorable aerobic conditions of fermentation. Other digesters main-

tain cells, bins under anaerobic fermentation. In some of these instances starters or activators or cultures are added. The best-known processes are connected with such names as Earp-Thomas, Frazer, American Composter Company. All these methods will produce compost. Whether they can handle garbage at the rate of 100 or more tons a day and do this economically is another question. In introducing his method, the writer of this article has had all the others quoted against him in being told it cannot be done economically.

It is evident that frequent turning of piles is a handicap. Likewise it is evident that unsorted garbage containing trash, glass, tin cans, china, is a serious handicap. The Pfeiffer Process suggested the use of sorted garbage obtained by a separate so-called two-can collection. In municipalities where such separate collection is practiced, the problem is simple. The plant in Oakland, operated by the Compost Corporation of America, used a separating unit with a sorting belt, which was already in existence. This unit had been built and used previously by the Oakland Scavenger Company, for other purposes. The operation delivered a "clean" garbage. A magnetic pulley had been added, which removed tin cans and iron objects successfully. The initial expense for a sorting unit is high, and it will pay only in large-scale operations of 60 to 100 or more tons per day. It would, however, be prohibitive for small town operations of 10, 20 or 30 tons per day. No doubt in due time an experienced engineering company will come up with the solution, in terms of completely mechanical sorting.

This difficulty of sorting materials and the expense connected with it has led other companies to process garbage and wastes without sorting. The two best known of such processes are the Dana method, developed in Denmark, and the method used in Holland by the N. V. Vuilafvoer Mij. "V.A.M." in Amsterdam. In this case, the garbage is dumped unsorted, after maceration and smashing (the Dana Method) or whole, just as it comes from collection (as in Holland). At present, "V.A.M." is also using a "rasping" machine in a pilot plant. No cultures of any sort are added to these piles of material, which rot through the development of heat, but the fermentation takes 4 to 6 months and odors are present. The end product is screened in order to remove inert materials, such as tin cans, glass, etc. To see these processes in terms of American conditions, one has to realize that large amounts of material

would have to be stockpiled for at least 4 to 6 months. In the case of a city producing 1400 tons of wastes a day (Detroit, Chicago) stock piles holding 252,000 tons would be necessary.

The University of California (Richmond Engineering Experiment Station) maintains that garbage can be composted successfully in a short time without the addition of bacterial cultures. In their experiments, garbage was sorted, ground in an Enterprise (high speed) grinder and dumped in small piles. Sometimes the piles of material were reground, sometimes just shoveled over, i.e. several turnings were necessary. After heating, they were re-piled. This also leads to a compost. The cost of such a process, when one considers the amount of labor involved, will surely be prohibitive. Here, again, it is a matter of a method looking good and working well when it is a question of small amounts of material, but it does not solve the problem of the economic handling of large quantities.

The fact that the last described methods work without using bacterial starters is occasionally used as an argument against the Pfeiffer Method which uses a starter. Of course, one can obtain compost without the use of a bacterial starter. Composting without the addition of a starter is found all through history. In such cases the organic work is done by various organisms which just happen to be present in the waste materials. It would be ignoring scientific progress if we were not to investigate the use of bacteria cultures especially suited to the purpose. Those familiar with the science and practice of fermentation in industry know very well that controlled fermentation, operating with specific yeasts or cultures, works economically and successfully to produce, in engineered processes, end materials excelling in quality. No good wine, beer, baker's yeast, antibiotic, lactic acid, or vinegar could be made were it not for the fact that definite, well-known cultures are used as "seed."

The author undertook a painstaking study of all suitable micro-organisms before he arrived at his solution of the problem of a bacterial starter. In it, selected organisms, concerning which all laboratory, microbiological and biochemical data are known, are used in a well-determined ratio in order to produce a directed fermentation under controlled conditions. Specific mixtures for definite purposes have been developed, for instance, for wet garbage, for garbage containing a lot of paper, for industrial wastes, etc. The Biochemical Research Laboratory, Spring Valley, N. Y., has developed bacteria in a concentrated

form (known as B.D. Compost Starter) for the composting of various industrial wastes. A list of such materials which can be treated successfully with the Starter includes bagasse, filter mud or cachaza, cannery wastes, coffee grounds, corn cobs, cotton gin wastes, ramie and kenaf wastes. Other materials which have been treated with Starter with equal success include fishery wastes, hair, tea leaves, cocoa tankage, flax shives, rendering offal, night soil, municipal garbage, sludge, straw, synthane chips (a plastic), and wool wastes. The treatment of sawdust is still in the experimental stage and sulfite liquor is under investigation.

The laboratory is in a position to study specific problems submitted to it. Suggestions for the proper formula for a particular fermentation can then be formulated as a result of such studies. It will usually take from two to three months to conduct a laboratory test. In connection with any special problem, please state the nature of the material and send a five-pound sample of it, for testing purposes, to the laboratory.

The B.D. Compost Starter will decompose only organic materials. It is not harmful to living organisms. It should be noted also that bacterial action may be slowed down, but will not be otherwise impaired, by cold and frost.

The laboratory has worked out and suggested various mixtures of organic source materials in order to obtain the conditions most favorable to fermentation. The aim is a carbon to nitrogen ratio of between 20:1 and 11:1 (optimal effect). That is to say, the whole equipment of the analytical laboratory has been employed in order to get an understanding of all phases of the process. It can be stated that under such conditions, composting is no longer a chance proposition, but rather an exact, quantitative science. Laboratory tests and calculations made in my laboratory differed by only 0.2% from the analysis of the product which was obtained many months later in the industrial application of the process. We refer to the final chemical formula of the finished product. Only if composting has been made a quantitative science is it possible to work out the economic problems involved in the processing, and to determine both the costs and the exact procedures to be followed. At present, all raw source materials are tested with suitable strains of bacteria, the C:N relationship is investigated and the actual procedure for large-scale operations is tried out in the laboratory before erecting a plant. The process in the plant is constantly

checked by analyses and the fermentation is controlled. All this enables the manufacturer to avoid costly operations such as frequent turning of piles, long waiting periods for the piles to be completely rotted; also avoided are undesirable odors, and losses of organic matter due to oxidation (burning up).

We here show, by way of illustration the analysis of a typical compost, an organic fertilizer made from city wastes.

Mixture of Raw Materials Used:

Garbage 70% Manure 20%
Soil 10%

The garbage mixture contained 1/3 of its weight in paper and cardboard wastes, i.e. 23% of the total mixture. It was average city garbage collected in late winter. The material was completely digested and air-dried to a moisture content of 20%. Swill produces a considerably higher analysis than the one given below as "average." Organic matter was 27%, the balance being mineral compounds.

Total Nitrogen: 1.0% *on the average.* During spring and summer, when more vegetables are used, the nitrogen climbed to 1.4%. Changing the formula by including poultry manure, high protein cannery wastes, such as pea vines, asparagus wastes, soya, fish, and meat wastes, tends to increase the nitrogen content to 2%. Nitrate nitrogen: 0.3%, ammonia nitrogen: 0.001%. The bacterial action is directed in such a way that nitrogen increases but free ammonia is avoided.

Total Phosphates: 2.0% *on the average*, with a fluctuation between 1.6% to 2.4%, the latter resulted from the use of fish wastes. Bone sometimes increases the phosphate content to 3%.

Available Phosphates: 1.8% *on the average*, with a fluctuation not below 1.5%. This high availability is due to bacterial action and is a typical feature of treatment with the B.D. Compost Starter.

Total Potash: 1.0% *on the average.* The addition of green plant material, leaves, wood ashes, bark and seaweed can bring the total potash up to 2%.

Available (water soluble) Potash: 0.56%. Continued bacterial action makes almost all potash slowly available.

Exchangeable Calcium: 0.5%; *Free Sulphates*: *none.* Due to bacterial action the compost has a neutralizing effect on both acid and alkaline conditions, as field tests have demonstrated.

Trace Minerals:

Magnesium	0.2%	Manganese	trace
Copper	trace to 20 ppm	Cobalt	"
Zinc	trace to 10 ppm	Titanium	"
Boron	10 to 20 ppm	Iodine	"
Iron	low (it is desirable to keep iron at a low level)	Molybdenum	"

Lead, arsenic, barium and chromium were absent in our sample. However, these are not desirable.

pH: *between* 7.2 to 8.0. It is possible to obtain a slightly acid compost with a pH between 6.0 and 6.5 if this is required, and specific fermentation processes are used to produce this result.

Bacteria Content: On the average, *air-dried compost* has a bacteria content between 20 and 50 billion aerobic bacteria per gram, and 100 to 500 million anaerobic bacteria per gram. Typical soil-humus bacteria make up the major fraction if the B.D. Compost Starter is used. Actinomycetes and streptomyces are present, accounting for about 10% to 20% of the total content. The *dehydrated compost* at a moisture level of 6% to 12% has a bacteria content of 10 billion aerobic bacteria per gram, which is a typical result of this dehydration process. The bacteria counts are made using the plate counting method on beef agar peptone after 48 hours of incubation at 29°C for aerobic organisms, and on Brewers plates with anaerobic agar medium containing sodium thioglycollate, for anaerobic bacteria. The anaerobic bacteria count varies from 100 to 300 million per gram. In the dehydrated compost the microorganisms are in a latent state but revive as soon as moisture is added.

It is possible to enrich a compost fertilizer by using different raw materials for fermentation. It is also possible to bring this about by adding minerals (fertilizer, rock meal, rock phosphates, etc.). Available fertilizers should be added to the finished product, after fermentation. Rock meal and rock phosphates should be added before fermentation in order to profit from their increased availability due to bacterial action.

The addition of nitrogen has been tried. Urea shows the best results when the total nitrogen content does not exceed 4%. Preferably the enriched product should contain not more than 3% total nitrogen. Ammonium sulfate has also been used, but it is preferable to keep the total nitrogen below 3% and the

ammonia nitrogen not higher than 2%. These proportions have been found to be the most successful in field tests with growing crops. After application, there is a slow but steady release of nitrogen in the soil due to bacterial action. In this regard, the behavior of organic humus composts is entirely different from that of inorganic fertilizers. In comparative field tests, it has been found that an enriched compost with a 4% total nitrogen content produced the same yield as a 16-20 fertilizer on a pound per pound basis of application, in the case of tomatoes, corn and lettuce. In other words, the bacterialized compost makes possible an economical and long-lasting use of its nitrogen compounds. Ammonium nitrates are not suitable as admixtures, for in organic compounds they may lead to spontaneous combustion.

Phosphates can also be added, but not more than enough to bring the formula up to 4% is necessary. While phosphate fertilizer may be locked up in soils and become unavailable, especially in alkaline and dry soils, the continued bacterial action will provide a steady availability of phosphates in bacterialized composts.

Potash can be added in any form. It is advisable not to increase the potash content above the total level of 4%. The availability of potash is much increased through bacterial action in the soil, especially in soils with a high organic content.

Agricultural limestone (a source of calcium) can be added to acid composts when large amounts of cannery wastes have been used. Magnesium can also be added. Dolomitic limestone is preferable because of its magnesium content. In general, an addition of 100 to 200 pounds per ton of compost will be sufficient. Leafmold compost and softwood sawdust compost may require the addition of larger amounts of calcium than composts made from city wastes. Lime should be omitted from composts intended for acid-loving plants.

The addition of trace minerals did not seem necessary in the case of our municipal waste compost and has not yet been thoroughly investigated.

Dependent upon the raw materials used and the type of fermentation applied, there are as many kinds of composts as there are brands of fertilizer. The final product ought, therefore, to be sold under a guaranteed analysis in order to avoid disappointment on the part of the purchaser. We have seen composts with as low a nitrogen or phosphate content as 0.4%.

These were used by the customer as "compost" just as he would have used others with a nitrogen content of 2%. Then people report that they have tried compost but that the results were not satisfactory. In the interest of the customer and in order that he may be able to determine the proper rate of application, it is necessary that he know exactly what he is buying, rather than just "compost." One ought to know the ingredients and the moisture content of a compost which one is using. For instance, it is generally agreed that 10 tons of farm manure per acre will produce a good crop and maintain the fertility of a soil. This barnyard manure contains 0.6% nitrogen and phosphate and 50% or more of moisture. Dry steer manure in California tests 1.5 to 2% nitrogen and 15 to 20% moisture. We can see from these two analyses that only half as much of the dry steer manure would be needed to equal the effect of a 10 ton per acre application of wet barnyard manure.

Another objection which is often raised against the use of composts is that their structure makes for difficulty in spreading. Loose, bulky, homemade compost must be spread by hand. A manure spreader sometimes works in certain instances and fails completely in others. The right spreading method is important for large-scale field application and determines whether a farmer or grower can afford to use compost. Hauling whether by truck or freight car is an expensive proposition nowadays, and the cost of transportation over long distances may make the total end cost of the product prohibitive. Homemade compost, like barnyard manure, usually has a moisture content of 50% or more. It is too expensive to ship such a quantity of water. This has led to the concentration and dehydration of composts and the development of organic fertilizers made from these dehydrated materials. Dehydration by air-drying is feasible in the Southern States or wherever climatic conditions permit. Otherwise a dehydrator has to be used. This too is an expensive item. A small production of say 10 to 30 tons per day may not justify the investment in a dehydrator unless cheaper devices of this nature than those at present available are designed. At a higher rate of production dehydrators can very well be economic investments. Dehydrated compost (organic fertilizer) is a concentrate and will save on shipping costs. It can be applied at a much lower rate per acre, for instance 1 to 3 tons per acre, which also decreases the labor of spreading. We use a rotary-trailer lime or fertilizer spreader behind a truck

and can easily cover one to two acres in half an hour, that is at the speed the truck can travel over the field.

For home use on lawns, and also on farms, some customers demand a product which can be used in a fertilizer spreader of conventional design. Here a pelletized product is needed. Up to the present, the pelletizing of compost was difficult and required costly machinery. Now a new process has been developed by the Biochemical Research Laboratory in which the pelletizing takes place during dehydration. This method is cheap enough to make pelletizing worthwhile. Dehydration and pelletizing have to be done in such a way that the microorganisms in the compost and its structure are not destroyed. This is possible, as we know from experience, but we have seen dehydrated manure which had lost its "wetting" capacity and was "sterilized." The pelletized product can also be used as a side-dressing on row crops in ordinary fertilizer spreaders designed for such use. Side-dressing has proved to be a very practical means of applying organic fertilizers. Good results have been obtained by side-dressing as little as 600 pounds per acre.

For carrying out these various operations, a composting plant consists, to begin with, of a receiving platform where all incoming materials are stored. A conveyor then brings the source material to a grinder or macerator. Hammer mills are not suitable for this operation, grinding hogs or rasps are preferable. Materials which would be abrasive are added after the grinding. A mixer is useful at this stage. The ground-up and mixed materials, which have also been inoculated with the bacterial starter, are then dumped in fermentation piles. A dump truck is used for transporting them to the piles. These piles, with aerobic fermentation conditions, have a "critical" size; i.e. they should not be higher than five feet or wider than twelve to fourteen feet. They can be as long as desired. As a brewery has a brewmaster, so the composting plant needs a compost master who is thoroughly familiar with the fermentation process and knows the behavior of all the raw materials as well as the proper mixtures to be used.

The fermentation can be conducted in such a way that no obnoxious odors develop. It takes from two to four weeks, depending on climate, temperature and moisture. The control of moisture is essential. With dry materials and in dry, hot climates, the addition of water may be necessary. Very wet piles rot entirely differently. A reduction of excessive moisture can be brought about by the addition of dry source material, by

allowing the piles to "steam out," and by turning or shaping up piles. This last is done relatively cheaply with a frontend or turn-over loader at a cost as low as fifty cents per ton.

After the fermentation is complete, the compost is air-dried by flattening out the piles and disking them. The material is then moved to a dehydrator or, if sufficiently dry already, directly to the screen in order to remove lumps, stones, and any objectionable bulk contents. The air-dried or dehydrated material which is ready for storage and bagging should be conveyed to a storage bin under a roof, or to a silo type shelter. Dry compost, below 20% moisture, does not change much, and keeps very well over long periods of time. As soon as the moisture rises beyond 20%, bacterial action begins again. If the material is sold with a guaranteed fertilizer formula, the moisture content has to be constant and dehydration is a must. Bagging of the dry material is simple, standard equipment can be used. Burlap bags draw too much moisture from the air. Therefore, polyethylene lined bags, or a three-ply bag with an inner layer of asphalt impregnated paper are preferable. In such bags the dehydrated compost keeps indefinitely without losses.

In northern, cold climates the grinding and sorting machines should be under a roof and in slightly heated rooms. The piles can be built in the open. If a pile freezes up, this will delay but not impair fermentation. Cases have been observed where the piles heated up and never froze despite low air temperatures. Even a two-foot snow fall melted away on them. Towards the end of the fermentation a wet pile may freeze, at least on the surface. When thawing, the material falls apart nicely. Certain soil bacteria continue to grow at freezing temperatures. However, in cold climates one might reckon with a somewhat slowed fermentation, and therefore figure on a certain amount of stockpiling. When frozen chunks are picked up for dehydration, a hammer mill may be needed to break them. All this means that in regions with cold winters the operation of a composting plant will be somewhat more expensive, due to extra handling and buildings, than it is in moderate and warm climates. In areas of low rainfall all the operations can be carried out in the open, and no costly buildings are necessary.

Finally, a word as to sales and market conditions. Growing out of the nature of agricultural production, sales are seasonal according to the times of the year when the farmer applies manure or fertilizer. Stockpiling of the product during the dead season is necessary. A compost company which processes municipal wastes arriving every day should therefore have enough operating capital to bridge over the stockpiling period for a product which is mainly sold in spring and fall.

The trade, which is used to handling so-called high grades of fertilizer concentrates with 6, 10 or more percent of nitrogen and phosphate, sometimes wrinkles up its nose at the "low grade" formulae of compost fertilizers. Here an educational program is necessary in order to demonstrate that composted organic fertilizers behave entirely differently than do the inorganic-mineral fertilizers. In the former, nitrogen is released slowly but steadily over a long period of time and therefore no losses occur. Phosphates, due to bacterial action, remain available and are not tied down. Also, the organic matter in the compost is wanted in the soil. What this comes to in terms of amounts is that where 500 pounds per acre of a "high grade" fertilizer are needed, one may use 1 to 2 tons per acre of a compost fertilizer. The price of the compost therefore has to be adjusted in accordance with what the farmer pays for his soil nutriments on a competitive price scale. Putting organic matter into the soils as the major means of maintaining fertility and structure is the chief object of compost application. The depletion of organic matter has been tremendous in recent years. Organic matter, where the soil is deficient in it, cannot be replaced by mineral matter. In this lies the future of composting which—if properly applied—will also contain all the mineral nutriments plus microorganisms to enliven the soil. A compost concentrate, as outlined above, has twice to three times the fertilizer value of manure on a pound to pound basis. Since the purpose of organic fertilizers is different from that of mineral fertilizers formulas cannot be exactly compared on a percentage basis. This should always be borne in mind when establishing the price policy of a composting plant.

The problems of organic fertilizing have been discussed frequently and in detail in previous issues of this magazine. The interested reader is referred to earlier numbers. Further laboratory and field research continues and will be reported on from time to time.

COLOR SYMPTOMS IN PLANT DEFICIENCY DISEASES

ERICA SABARTH

The material presented in the following article has been brought together by the author from notes of a vivid and exciting lecture which she gave last summer at the B.D. Conference. Mrs. Sabarth has been active in both a practical and scientific way in the biodynamic movement both here and abroad for many years. Last summer for the first time, she was prevailed upon to speak at a B.D. meeting, and now at the urgings of those who heard her she has put some of the material into written form.

Color is a most important and helpful indicator in judging the state of health or vitality of any living organism, be it plant, animal, or human being. A physician, when making a diagnosis, will not only check the pulse and temperature of his patient in addition to listening to the various complaints, but he will also take careful note of the color of the face, the texture of the whole skin. He knows there are not only the extremes of a pale face drained of all vitality, or of the over-red, flushed face pointing to some kind of congestion, he also knows that there are *many shades and transitions of color* which can give him a helpful additional clue for his diagnosis.

The farmer and the gardener can be thought of as being more or less in the position of a doctor, taking care of and checking on the health and well-being of their plant children. In spring as the farmer walks over his land he will enjoy the healthy, bright green of his fields, but he will also have an open watchful eye for any color deviation in his plants informing him that they are for one reason or another not doing so well, not feeling so happy.

Just as we associate rosy cheeks with a healthy child, so we connect green not only with the plant world as a whole, but with the healthy plant in particular. The color green in the plant realm is the color of perfect health and balance. It tells us that such a plant finds all it needs for the upbuilding and maintenance of its different organs, and that these nutrients are interacting in the plant in perfect balance. Any unbalanced plant nutrient condition will show up as a change in the green characteristic of that particular plant.

If we ask ourselves, upon what does the health of a plant depend, we will find that the most important factors are moisture and sunlight, and of these two sunlight takes precedence. It

is the light which enables the plant to build up, to synthesize its own substance. This most fundamental of all biochemical processes, this synthesis, takes place in the green part of the plant, in the leaves. Through its leaves the plant takes in the carbon dioxide from the surrounding air and, in the presence of water and with the help of the sunlight, it converts this carbon dioxide into carbohydrates, into starch, into sugar, into cellulose. Without the sun, without the warmth and light of the sun, no plant can exist or grow for any length of time. Nor would any plant be green without the light. You have all seen potatoes which have started to sprout in a dark cellar or in a burlap bag. If you leave them there in the dark, they will develop long shoots but you won't detect any green in these sprouts, they will remain a sickly white. When you put your seeds in the ground, the little germ which develops will be whitish yellow as long as it grows in the soil, and only when it emerges above the surface of the earth and receives the sunlight, only then will it start to become green. Even when plants have already developed the green color in their leaves, they will lose it if deprived of light. A common example of this is what happens when you forget to pick up a board which has been left lying on your front lawn. There comes the day when you do remember and by that time what once was fine green grass under it has turned pale.

The greenness which is so closely connected with the sunlight, is, as is well known, produced by the chlorophyll in the plant leaf. This chlorophyll, the carrier of the green color, has the same chemical constituents as the hemoglobin which makes our blood red—with one exception. We have iron in the hemoglobin, the plant has instead magnesium in its chlorophyll. And just as any disturbance in our body will be mirrored at once in one way or another in our blood, so, in the plant, the chlorophyll is the most sensitive part, the first to react to any disturbance. The leaves may thus be considered to be the best indicators of the condition of the whole plant. Their reactions can range from a slight drooping or wilting on a too-hot summer day to a complete color change as occurs naturally in fall after the leaves have fulfilled their task, after the plant has matured and the new plant is built up in the seed. Then the chloroplasts, the bearers of the chlorophyll fade away, the green disappears and yellows and reds in all their beautiful shades delight our eyes. These yellows and reds were already there in

the leaves, but they were somehow over-shadowed by the strong, vigorous green of the living, growing leaves.

The appearance of yellows, reds, purples, and other variations in color in the leaves of plants, out of time and out of place, can serve as symptoms of lacks in plant nutrients, of what are nowadays called deficiency diseases. For instance, when the farmer discovers yellow leaves on his corn or his wheat before they have matured, say in the late spring, then he starts to worry, because he knows that this is a sign of a disturbance in the plant, that something is lacking. He wants to know, of course, just *what* is needed to restore his crop to health. Arriving at a specific diagnosis and remedy is not as simple as one might have begun to think. However, if we study these color changes in plants carefully we will find that there are differences in the way in which they take place, in the course followed, in the area affected, as well as in shadings of transitional tones. These subtle variations in the color changes enable us to make what we might call *differential* diagnoses of the ailments of our plants.

To return to the farmer with the ailing crop of corn, if the yellowing occurs in such a way that at first the tips of the lowest leaves turn light green, then lemon yellow to orange yellow, and this color change spreads along the midvein of the leaves down toward the base, he can be fairly certain that his corn is suffering from a nitrogen deficiency. In cases of more extreme deficiency of nitrogen, the leaves will dry up, again from the tip downward, showing the so-called "firing" symptom. In addition to these characteristic color changes, the further development of the plant is affected, growth is retarded, the plant looks stunted and spindly, and may even stop growing altogether since nitrogen is one of the most vital of plant nutrients. It is needed for the growth and development of all tissues, is the essential element for the production of protein, and has an influence on the respiration.

There are about 75 million pounds of nitrogen in the air above every acre of land, but in this gaseous form it is useless for the plants. They have to take up the nitrogen with their roots from the soil where it is present as nitrates or ammonia. In the plant cells these nitrate salts are then converted into amino acids of which there are a large number. These amino acids are then recombined to form protein. Part of the nitrate, as such, accumulates in the plant and represents the chief inor-

ganic nitrogen reserve of the tissues. In corn the highest concentration is usually found at the base of the stalks and becomes progressively weaker toward the top of the plant. A rhythmical change in this concentration has also been observed, the lowest nitrate content being in the early morning, then it increases, reaching its peak somewhere between 11 AM and 3 PM, after which it decreases again.

Another color symptom which can be looked for in the case of corn is a purplish shading on the leaves. A prolonged period of cool weather in spring may cause such a purpling but this will be more or less temporary and vanish again. Then too, there are strains of corn which show this purpling in perfectly healthy plants. *Such plants have as an innate quality a strong factor for the production of purple pigment.* It is, therefore, important to become familiar with the appearance of the healthy plant before judging as to nutrient deficiencies. If, however, the purpling is more intense than normal, or appears in corn which does not usually have a purple cast, then the plant informs us with this color symptom that it does not have enough phosphate. This purple color is due to the effect of accumulated sugars on the formation of purple pigment (anthocyanin), and phosphate starved plants will continue to form sugars to such an extent that the amount becomes abnormally large.

Phosphate is, of course, another of the nutrients important to plant growth and development. All plant cells contain phosphate and it is especially needed in the process of cell division; if the supply is scarce, the rate of cell division is slowed down and the plant will remain stunted. Inorganic phosphate as such is present in the cell sap and concentrated in the tips of the roots and shoots. It is also found in the developing kernel of the grain. Thus we find in phosphate deficient corn another sign, that of slow maturity, especially noticeable during pollination. When the silk emerges slowly, defective ears are produced, with incomplete rows of seed.

Plants with an extreme phosphorus deficiency may also show signs of a lack of nitrogen. The reason for this lies in the fact that these two plant nutrients are closely interrelated. In this case, phosphorus acts as biocatalyst in the assimilation of the nitrates. The phosphorus deficient plant cannot make use of the nitrate salts, and the plant tissues may actually starve for nitrogen, even though they contain nitrate salts.

Another abnormal growth picture points to a lack of potassium. The leaves of the corn plant, for example, will seem too long in comparison to the stalk. In addition, the older leaves turn yellowish green to yellow. The difference here as contrasted to the yellowing caused by a nitrogen deficiency, is that the tips and *edges* of the leaves are affected first. They may become dry and appear scorched when the lack of potassium is greater. This marginal scorch is the outstanding leaf symptom for a potassium deficiency. This plant nutrient is intimately related to the production of sugars, cellulose and proteins in the plants, but it does not enter permanently into the composition of any of these organic compounds. It is needed in all the processes of growth in the plant cells and also influences their rate of respiration. Potassium enhances the plant's ability to resist disease, cold and other adverse conditions. One might almost call it a kind of "vitamin" for plants. It also plays the role of biocatalyst in the process of photosynthesis.

When we turn now to color symptoms of magnesium deficiency, we find quite a different sort of yellowing or fading in the corn leaf. This begins as a yellow streaking between the parallel veins in the leaves. At first, it will show as light green, then light yellow, and finally there is a definite and sharply defined series of yellowish to white streaks extending the entire length of the leaves. The oldest leaves show the symptoms first, in acute stages they will dry up and die.

When, however, we note a change from green to pale green at first in the terminal growth of the corn plant, in the *young* leaves, then we have to do with an iron deficiency. Plants need very little iron, yet it is a very essential element for them. The presence of iron enables a plant to produce its chlorophyll. The chlorophyll itself does not contain iron, as has been noted earlier in this article, but the chlorophyll will not be produced in a plant unless some iron is present.

The small grains show the same symptoms as corn, pointing to the same deficiencies in regard to the various plant nutrients we have dealt with so far. It is easier to detect these variations in color changes in the broad leaves of corn, however, and consequently easier to describe them without illustrations.

When we go from the fields to the garden, the vegetables, we will observe, in general, the same symptoms, but there are also quite a number of additional features to help us in our differentiation. For instance, a nitrogen deficiency in the tomato

not only appears in a fading out from green to light green, to yellow, even to a deep golden yellow, but at the same time the veins in the leaves change from a yellow-green to a deep purple. The stems of the plant become hard and fibrous, the roots stunted. In extreme cases the whole plant turns brown and dies. The flower buds turn yellow and then drop off.

In the potato, close relative of the tomato, a lack of sufficient nitrogen results in the restriction of the entire growth of the plant. The quality of the tuber is, of course, also affected. The whole plant assumes a light green to pale yellow, and in advanced stages the same shedding of the leaves occurs.

A potassium deficiency in the tomato affects the younger and the older leaves in a quite different manner. The young leaves change in texture, become very finely crinkled, while the older leaves first turn an ashen grey, then yellowish along the margins, finally bronze. This is followed by the development of colored spots between the larger veins. The affected areas often turn a bright orange color and become brittle.

The potato, on the other hand, exhibits an additional symptom when on short rations of potassium, with which we are already familiar. The internodes are much shorter than usual, giving the whole plant a compact appearance. The leaflets are reduced in size and form a sharp angle with the midrib. They also lose their smooth surface and become wrinkled, the tissues between the veins protruding more or less strongly. The edges of the leaves bend downwards. Preceding the yellowing of the leaves, which again starts from the margins, the foliage is generally of an abnormally deep green color. The tubers produced by such plants tend to turn dark when boiled.

We now add a few notes on color symptoms and other changes as they may appear in various garden and field plants. Finally, there is some material on what is known about the signs of two or three other mineral deficiencies.

CABBAGE. The marginal color change and scorch of the leaves, typical of a potassium deficiency, is also found in cabbage. With the absence of magnesium, the leaves of the cabbage first appear mottled and parched. Later, the mottling develops into pale yellow areas around the rim and at the center of the leaf. These areas finally rot and die.

CUCUMBER. A lack of nitrogen not only shows up in the leaves of the cucumber vine, but the blossom ends of the fruit range from pale yellow to brown and are apt to be pointed in-

stead of well rounded out. The whole cucumber is lighter in color than normal. A potassium deficiency appears in the characteristic bronzing and dying of the leaf edges. The fruit, in contrast to the nitrogen deficient cucumber, has an enlarged tip and an underdeveloped stem end.

SOYBEANS. The color changes in the legumes follow a slightly different pattern than others noted so far. For instance, with a nitrogen deficiency in the soybean, chlorosis and yellowing spread evenly over the entire leaf, starting at the base of the plant. There is slow growth, a decrease in branching, and smaller plants at maturity. Again, a phosphorus deficiency does not show up as a purpling in legumes, but rather in an intense bluish green, as well as in a stunting of growth.

ALFALFA. This legume exhibits the typical marginal scorch of the leaves in the event of a potassium lack. When this "disease" is far advanced the leaves look ragged. Clovers, on the other hand, react in a slightly different manner to potassium starvation. At first, yellowish to white dots appear at the tips and around the edges of the leaves, then these dots merge with one another.

BORON. Boron regulates the fluid relationships of the plasma colloids and is especially active in the transportation and utilization of the carbohydrates. Without boron, starches and sugars accumulate at the points where they are synthesized within the leaves and cannot be carried to other places in the plant where they are needed. Boron is also required for flower and seed production. It is found in traces in most vegetables, and if it is missing results in definite signs of disease. In the legumes, for instance, we will find a reddish brown area around the margins of the leaves.

Cauliflower is especially sensitive to boron deficiency. It reacts with an internal browning of the head. This begins in a small water-soaked area in the stem and central branches of the curd. Cauliflower so affected has a bitter taste, raw as well as when cooked. The browning of the head spreads in extreme cases of boron deficiency; there may be an outer as well as an inner discoloration. Since cauliflower is so sensitive to a lack of boron, single plants are often set out amongst other crops to serve as indicators. Celery is also fairly susceptible, and shows the well-known cracked stem, as well as a brownish mottling of the leaves. First, the stem becomes brittle, then brown stripes appear along the ribs. Finally crosswise cracks

appear on the surface of the stalk and the tissue curls outward from these breaks. This disrupted tissue soon turns dark brown.

CALCIUM. This element influences the translocation and physiological availability of the nutrient elements in the plant. It also acts as a neutralizing agent, preventing the accumulation of toxic or too acid materials in the plant tissues. It exists in a delicately balanced relationship with magnesium, potassium and boron. Any upset in this relationship, or the lack of any one of these four elements, will result in an abnormal performance of plant functions. For instance, an apparent excess of potassium, magnesium, or boron, may really be a deficiency of calcium. Calcium also acts as support between the walls of plant tissues, holds them together, being deposited in the cell walls. With a calcium deficiency the youngest leaves of the corn plant develop hook forms on their margins. Whereas, when boron is lacking, the young leaves of the terminal growth show breakdown at their bases. Death of the terminal growing points is the final result in both cases. In garden peas, however, a calcium deficiency appears as a color change. Red patches appear on the leaves, at first near the midrib and at the ends of the small veins, later spreading over the whole leaf. The healthy green of the plant gradually becomes pale green and finally white. The basal portion of the leaf changes first, the margin holds its greenness longer.

MAGNESIUM. In addition to the other specific things spoken of concerning the functions of magnesium within the life of the plant, it is important to realize that it influences the earliness and uniformity with which vegetable crops mature. It also has an influence upon the size of the root as well as on the size of the fruit, but above all upon the *quality* of the fruit.

This field of plant disturbances and their diagnosis by means of color symptoms and abnormalities of structure is, of course, a wide one, full of much material which has not yet been investigated.* There are, naturally, many more varieties of color changes and variations in structure and growth, but those dealt with in this article are the main ones and those most readily described without illustrations. You can see from these that the plants have many ways of letting us know that something

* The reader interested in a fuller study of the material presented here is referred to the book Hunger Signs in Crops, A Symposium, edited by Gove Hambidge and published by The American Society of Agronomy, Washington, D. C.

is disturbing them and what it is, so that we can lend a healing hand (if it is not too late). One language they use is that of color changes and variations, and this is the set of symptoms which speaks most clearly to us and can be readily noted by us.

EVEN SCIENTISTS HAVE TO EAT!

Do you have some treasured recipes which you would be willing to share with readers of Bio-Dynamics? They should not be copied from another publication but something you have originated or adapted and perhaps used so long that you can't remember where you got it. We would prefer things not too difficult to make, but utilizing nourishing materials in a practical way, possibly a recipe you use almost daily or else as an occasional break in the menu. Dishes well liked in other countries would be especially welcome. Here are a couple of which I am fond. If you would like more, send in your contribution.

Yours for a recipe exchange! EVELYN SPEIDEN

SESAME SEED ICEBOX COOKIES

½ cup sugar
½ cup honey
¾ cup melted shortening or peanut oil
1 egg, beaten
2½ cups wholewheat flour, sifted
2 teaspoons baking powder
½ teaspoon salt
¾ cup browned sesame seeds (hulled)

Cream sugar, honey and shortening thoroughly. Add egg. Mix flour, baking powder and salt and sift again. Combine these two mixtures and add sesame seeds. Shape into long rolls not much over an inch in diameter, and wrap in waxed paper. Place in icebox overnight (may be kept longer). While cold and firm cut into ⅛ inch slices and bake on ungreased cookie sheets. Temperature—375 degrees F. Time—10 minutes.

SESAME COOKIES (more delicate than the above)

¼ cup butter
½ cup brown or raw sugar
1 egg, beaten
½ cup wholewheat flour, sifted
½ teaspoon baking powder
salt—a pinch
½ cup browned sesame seeds (hulled)

Cream butter and sugar until light, add egg. Mix and sift flour, baking powder and salt and add to first ingredients. Add sesame seeds. On greased and floured cookie sheets, drop pieces the size of a marble, far apart. Temperature-375 degrees F. Time—8 minutes.

VITAMIN C ALL WINTER

If you have both garden and freezer, plan to have peppers and parsley in quantity for the garden this summer. Select early varieties of large, sweet bell peppers and give them an early start so many will ripen. Contrary to many opinions, they do not get hot on ripening but more mild and sweet. They add attractive color to many dishes. Most important—the vitamin C content doubles on ripening. You'll probably find that many folks who don't like or cannot eat green peppers, will take them red.

Harvest when deep red, wash quickly and thoroughly in cold water (never soak), remove inner parts, stem and any soft spots and cut into small squares all ready for use. Prepare parsley in the same way. An old fashioned chopping bowl is the most handy tool for cutting it up quite fine. Pack it closely into container. Neither of these needs blanching. A fairly small container with easily removable lid is the most convenient so that you can take out as much as you need for one occasion and put the rest back in the freezer. You'll be surprised how often you will use one or the other, or both, of these to add zest to winter dishes. Green peppers can be stored in the same way, of course, and you will have many of them at the end of the season which are too late to ripen.

VALUABLE MATERIAL STILL AVAILABLE

While you can still get them, order back issues of Bio-Dynamics to complete your file. The earlier issues are now exhausted but there are 24 back issues of which we still have a limited number of copies and which we can sell for 25c each. Why not present a complete file to your library? Or to interested friends? They contain a great deal of practical help and scientific explanations which will enable you to talk even more intelligently about the value of the Bio-Dynamic Method when your friends ask questions. Send to Bio-Dynamic Farming & Gardening Assoc., Inc., R. D. 1, Chester, New York.

NOTES ON CITRUS CULTURE

HAROLD S. RICHMOND

Those of us who have tasted the oranges grown by the author of the following valuable notes on his experiences and practices adapting the B.D. method to the climatic conditions of Florida, can vouch for their fine flavor. The editors are happy to greet an old friend and introduce a new one to new readers, in the person of Mr. H. S. Richmond of Maitland, Florida.

At the "Sugar Pill Farmacy," it is attempted, though in a manner short of perfection, to carry out Bio-Dynamic practices. The Florida sand presents its own baffling problems. I am still pondering how to get spray 500 down through the heavy mulch as a field application.

Whatever is done or omitted, there is a rule of fertilization with "Naturals" only as against "Chemicals." This does not necessarily brand me as a "cultist," and I need not make excuses any more than a man need explain why he chooses a purple necktie. That is simply a groove of research that I wish to follow. If better fruit can be had that way, as is believed, that is good.

Some peace of mind may be had through not having to worry too much about soil imbalance, as the chemics do. Soil analysis, and supplementation, if necessary, is not a delicate matter. Nature is a safer guide than theory.

With the mild slow acting naturals, schedules are easy to work out and fertilizing does not need to follow a precise timetable. The compost ought to be gotten out of the piles before the rainy season (beginning in June) is far advanced, to avoid leaching the piles. It is not wise to apply much nitrogen in the fall and winter and start a premature bloom, but probably there is less danger from this than with the chemical system. We do not let that consideration weigh too heavily.

The natural fertilizers include the manures, castor pomace, weed crops, Spanish moss, tobacco stems, saw-dust and other organics. Also powdered rocks, such as raw colloidal phosphate, dolomite and potash rock. Tobacco may not be very favorable to the grasses used as cover crops, and has to be used with discretion, but it is an economical source of organic potash, and the trees like it.

Mrs. Edith Hoffman, in her excellent pamphlet, "The Missing Link in Soil Conservation," stresses the value of shade as a factor favoring soil life. Since our trees are in general not large enough to produce the necessary shade, I am keeping on with mulching for this purpose. The demand for mulch is so great that there has been a shortage of vegetable fiber for the compost, which is therefore made up largely of manure. Ventilation has been afforded through frequent turning. It is believed that this problem will be solved by Pangola grass, a vigorous grower that has been introduced and which ought to be able to meet the needs of mulch and compost material.

Other grasses are grown. Centipede, a creeping grass used for lawns, is being encouraged although it is expected that it will be crowded out by the Pangola before long. The centipede is a low lying grass and is probably not a serious fire hazard nor a good harbor for snakes.

Non-cultivation continues to be the practice adhered to now for the past 7 years. The soil is undisturbed except when planting peas and such by hand, and attending to young trees.

Compost is applied by dissolving it in water and slopping the rich brown "broth" over the ground where it sinks instantly into the soil and is not burned up in the sun. Castor pomace is merely strewn upon the ground, lodging in the cover crop and mulch. This rich beany material takes care of the nitrogen needs, supplemented by natural fertilizers. It is eagerly absorbed by the soil and is relished by the trees and weeds. There is no fear that the weeds and grasses will get more than their share. The trees will get it in the end when the cover is mowed and rotted.

With non-cultivation, the roots of the trees are encouraged to feel for the nourishment and come to the surface, where they are in a more exposed position. Also there is the danger that a winter mulch will act as a baffle, interfering with "cold drainage" ie:—rolling of the cold air on a frosty night down the grade and away from the trees. In compensation for these disadvantages, the mulch affords protection against drying at the surface and strengthens the tree, making it more resistant to the cold.

With the system of naturals, irrigation with overhead sprinklers is of advantage to fight drought, especially during the terrible month of May, and before the summer rains take over. We always try to lay down 2″ of water at a time, which

is expected to penetrate over a foot and encourage the roots to go down.

Earthworms are now a part of grove economy and appear often in great numbers in the compost. They are distributed in the grove where it is hoped they will greatly multiply under favorable conditions and become a factor as fertility builders.

Amongst other grove helpers, the Manatee snail is becoming popular. This creature eats up sooty mold on the foliage and lichens on bark. When he has done his job the tree is a beautiful sight with the streaked bark shining as though burnished. A few snails were purchased from a large grove in which almost every tree had its colony. The owner said he had at first adjusted his fertilizer spreader to spread close to the trunks, with the result that the snails were killed where they had congregated close to the tres. The equipment was then readjusted to avoid a repetition of this disaster. It goes to show that the snail does not thrive upon the modern poisons, though they will tolerate a sulphur dust. It is our hope that these little missioners will become a factor in altering grower psychology, rewarding the grower who abstains from the use of the more drastic poisons.

The grove has apparently not suffered from lack of aeration due to non-cultivation. The soil is porous and if not flooded will probably continue to be fairly well permeated with air. The worms may help in this.

Barring heavy frosts, which as yet have not done much damage, grove practice at the "Farmacy" seems to be fairly established. This practice however, seems not to have the approval of the experts, who stress "proper" fertilization and pest control. Their grim warnings of the dire effects of ignoring their mandates, have not proven valid after years of violation of their decrees.

Now, how is fine flavored fruit produced? First, as every one knows, a fruit should be ripe. Restraint in the use of nitrogen should prevail, getting the foliage a medium but not a black green. Rank growth will then be avoided and the trees will be able to probe for the trace elements in balance with the other elements. The writer, being a modest man, may ascribe some early success with fruit to having been so inept with fertilization and irrigation as nearly to starve his trees, for he did, without malicious intent, abuse his trees plenty, not safeguarding against burning of the unprotected soil and allowing the trees to get dry.

While this may result in fine fruit, we choose not to follow this practice as a standard.

Lavish use of vegetable matter as a mulch is desirable. Legume or weed crops might be grown in another field and then applied to the grove, while at the same time a heavy crop of greens is grown in the grove. This crop will help pump out excess moisture during the rains. Moderation in irrigation is desirable.

Probably with these precautions, a fine flavored and good *keeping* crop will be had. In this connection we have had a report that a shipment of oranges which had been hoarded because of the lateness of the season had kept about 3 months after shipment although the skins had shrivelled.

Pests still keep rather in the background. I have had troubles,—lichen on the bark—which could probably have been taken care of if my time and means were greater; foot rot and ruin of a few aged trees that had gone through the rigors of conversion from chemical to natural fertilization, and droughts without adequate irrigation.

Perhaps melenose, coming from rotting twigs of "die-back" could be classed as a pest. It is dealt with by pruning away the dead wood to prevent rains from washing the infection down upon the fruit and making it unfit to ship. I know of no pest-controls that could have been of use in these troubles and there is no temptation to use any poisonous controls.

It cannot be said that all pest problems are disposed of for all time. The dread tristeza that attacks trees budded upon sour roots is now reported to be established in Florida. Whether the conservative practices of Bio-Dynamics will safeguard against this and other troubles yet to appear cannot be predicted. All that has been said has relation to the set of pests that are now operating in force about the state.

Now, for some generalities.

"Science for science's sake" often ignores the practical necessities of the century. Sociological problems such as "population explosion" are slighted. The momentous problem of how to feed the exploding population rests lightly on the public mind, while the scientists propose solutions such as synthetic chemical food, hydroponics or other doubtful devices. Building fertility by fully exploiting the soil's biological resources so that enormous increase in food production may be possible is not given enough attention.

Fantastic poisons are being introduced and problems of residues in foods have become acute. One large packing company, to its credit, has sought to keep down harmful residues in its foods at enormous cost.

It is, however, no longer in order to plead inability to obtain pure unpoisoned foods with mineral, protein and vitamin content. Many producers now offer food raised under sanitary conditions. More will be brought into line when consumers insist upon having this kind of food. Fortunately good food and high production are not in antagonism. With soil fertility built to a high state, both these ends are achieved.

I venture to say that without public insistence upon having good food, it will not come about. Consumers to the fore, please!

PREPARATIONS AND STARTER

The Bio-Dynamic Preparations and the B.D. Compost Starter both produce a high grade compost material from manure, garbage, plant refuse, etc. For the average farm and for the home garden the preparations are ideal. They break materials down in ample time for use from season to season. The Starter, which is available only for experimental work and large-scale industrial operations, produces the same results more quickly. Fine grinding of the materials used in the heap is essential where the Starter is used. This is optional in connection with the preparations. However, with the preparations it is essential that the Spray 500 also be used on the land treated with the composted material. Use of the Starter makes the latter operation unnecessary.

Address orders for the Bio-Dynamic Preparations to the Bio-Dynamic Farming & Gardening Assoc., Inc., R.D.1, Chester, N. Y. The prices listed include postage.

	To Association Members	To Non-Members
502 –507, set of 6, for compost or manure piles up to 15 tons	$2.50	$2.75
500 per portion, for 1 acre, soil spray	.65	.75
501 per portion, for 1 acre, foliage spray	.50	.60
508 per portion, foliage spray for fungi, etc.	.30	.35

(Orders of over 7 sets or portions, 10% discount)

Do not address B.D. Starter inquiries to the Association. Any questions regarding possible experimental or large-scale industrial use of this material are to be sent directly to the Biochemical Research Laboratory, Spring Valley, N. Y.

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CROP ROTATION AND MIXED CULTURES

In forest, meadow and every wild plant association, there is a colorful mixture of plants, which, in accordance with soil type and local climatic conditions, are able to live together and mutually complement each other. We often speak of "natural plant association." The substances resulting from the decomposition of plants, the excretions of animals and all rotting organic matter, care for the formation of natural humus, which is held fast by the plant roots and utilized by them. In many regions plants associate in such a varied manner, that blossoms, green leaves and fruits hang beside one another up to the time of killing frosts.

A secret life hides itself in the underground rootstocks, bulbs and tubers of perennial plants, in the slumbering eyes of trees and shrubs. It lies there ready to push forward again with the increasing warmth of Spring and manifest itself anew in growing and blossoming.

Conditions are quite different in cultivated land, in field and garden. Here, in the course of *one* period of growth, plants are cultivated which often do not even ripen completely, except for the grains and certain fruits.They are supposed to develop the greatest possible leaf mass, as cabbage and spinach, for example, or to form large roots, like the turnip. Thus the plants make great and often truly one-sided demands on the soil. Cultivation of the soil and fertilizing are therefore necessary, the first to aerate and open up the soil, the second to supply nutritive substances and maintain a balance. Plants must alternate with one another in a succession which uses the ground without robbing it, and lets it rest again at intervals, so that it is not made one-sidedly poor in nutritive content. This means that we must use a crop rotation such as follows. In horticulture plants are classified according to their requirements and their more or less one-sided utilization of the food substances in the soil. They may thus be divided into *heavy feeders, light feeders* and *soil conserving and improving plants.*

HEAVY FEEDERS—All plants which need a heavy fertilizing with stable manure are heavy feeders. They can also utilize applications of liquid manure. Entirely fresh, untreated manure or liquid manure are not used, however, even for them. The heavy feeders are planted immediately after fertilizing. Those most familiar are all the cabbage varieties, cauliflower in particular, all leafy vegetables such as chard, head lettuce, kale, mustard, endive and spinach, as well as celery and celeriac, leeks, peppers, eggplant, cucumbers, squash, melons, pumpkins and corn.

Rhubarb and tomatoes are also decidedly heavy feeders, but are not included in the crop rotation because rhubarb is perennial and tomatoes are the one annual which likes to grow in the same place year after year. Even the stay-at-home tomato, however, sometimes needs a change after four or five years. They don't require a long journey; shifting to another part of the same garden area usually suffices. Berry bushes and strawberries likewise require a rich, but not a fresh manure, but are benefited by alternate applications of treated manure and compost, or by application of a mixture of the two. The results, in terms of flavor and fragrance of the fruit amply repay the gardener for this added labor.

SOIL CONSERVING AND IMPROVING CROPS—The heavy feeders can be followed by legumes. These include pole and bush beans, peas, edible-podded peas, broad beans, shell beans, black-eye peas, lima and soy beans and peanuts. Such plants bring about the recovery and improvement of soil which has been depleted by the heavy feeders. By means of their deep-growing roots legumes open up lower soil levels and bring to the surface again nutritive substances which may have been washed down (lime, for instance). The roots of many annual legumes reach to a depth of 2 feet; perennial types go even deeper, alfalfa and sainfoin reaching a depth of 6½ feet in a deep soil. By means of the nodule bacteria on their roots all the legumes capture the air's free nitrogen. In this way they provide for necessary nutritive materials and produce supplementary fertilizer. In a run-down soil, we should always plant them directly after the heavy feeders. In a live humus soil they can come later, in which case a light compost fertilizing benefits them.

LIGHT FEEDERS—It would really be more appropriate to call these "compost lovers." They cannot stand heavy fertilizing with manure, which will cause a rank, coarse growth. Instead they should be fertilized with well-fermented compost. We are dealing here with bulbs and all root vegetables, such as beets, carrots, radishes, salsify, parsnip, chicory, turnips, corn salad, kohlrabi, onions, leaf lettuce, etc. They stand to best advantage when grown after heavy feeders, but they can also be grown in third place in the rotation. To this group also belong annual and perennial herbs. With their aromatic quality they help to conserve the soil and "enliven" with their blossoms the vegetable garden, which flowers relatively little.

There are still some plants to be mentioned which, because of the peculiar character of their growth, their scent, root formation and soil demands, have a beneficial effect on the garden, being often useful as border plantings or as a hedge around the garden to break the wind. Although they make strong demands on the soil, they are biologically useful plants. Among these are corn, sunflowers, rhubarb, asparagus, tomatoes and globe or Jerusalem artichoke. Corn should always be planted in two or more rows to insure pollination, never in a single row. Tomatoes may be part of the border or in their special bed. Sunflowers attract the birds which then help us to control insect pests. The artichokes make good border plants, likewise rhubarb and asparagus, both the latter being perennial and requiring a permanent location. As border plants for the whole garden some of the taller growing herbs are excellent, especially if allowed to bloom freely as a feast for the bees. These could include any of the following,—sage, southernwood, wormwood, yarrow, rue, hyssop (especially near grapes), lavender, lemon balm, lovage, angelica, tansy, bergamot, catnip, costmary, stinging nettle and horehound. All these perennials or biennials can be located where one does not need to plow. Rosemary and rose geranium belong in this group too, but must be treated as annuals in the northern part of the United States.

Mixed border plantings within the garden can well be made of the lower growing herbs such as the perennials thyme, winter savory, tarragon, santolina, burnet, chives and garlic (good near roses) ; or the annuals summer savory, parsley, chamomile, chervil, dill, marjoram, basil (not near rue), borage (good among the strawberries), cress, and nasturtium. If you grow potatoes, plant a *few* horseradish among them. Fennel is an

herb which seems to disturb many other plants, especially bush beans and tomatoes. All the mints spread so wildly that they need a corner to themselves, possibly a damp and somewhat shady spot. Tarragon, parsley, lovage, angelica and chervil will tolerate some shade too, but most of the herbs need full sun.

If you can spare the space in your vegetable garden, by all means plant a few flowers as well as herbs. Modern specialization is not good for gardens. The instinctive wisdom of those monks who made the beautiful old medieval gardens brought vegetables, flowers, herbs, shrubs and trees into one thriving unit. Garden flax has an excellent soil loosening effect through its fine root structure. Carrots are especially grateful for such a soil. Besides flax, soy beans and lupines leave behind them the finest, most friable soil. Buckwheat and caraway are good cover crops to improve heavy, poor soil. Caraway germinates better if sowed with a legume.

It is not a matter of indifference in what associations plants are grown. We need only think how the shallow-rooting and deep-rooting plants supplement one another through the differentiation in their root systems. The legumes, for example, promote root growth in their neighborhood through the aeration of the soil resulting from their own deep-growing roots. It has been observed that beets and kohlrabi grow very badly near pole beans, if planted too late and consequently shaded by the beans. Between cabbages they thrive, even in a cramped and shaded position. Another unfavorable combination is tomatoes and kohlrabi. The one planted last generally suffers. While we value sunflowers in a border, along a path or in a meadow, it is not good to plant them near potatoes. We risk having stunted vines and small potatoes, especially if the sunflowers are luxuriant.

Among mutually beneficial combinations are cabbage and beans, beets and onions, celeriac and leeks, cucumbers and corn. Beans are not harmful planted near celeriac and leeks except if planted too thickly between them, when all three are generally stunted. Other beneficial associations are carrots and peas, cucumbers and beans, kohlrabi and beets, early potatoes and corn, early potatoes and beans, tomatoes and parsley, bush beans and celeriac, turnips and peas, bush beans and celery, cucumbers and peas, onions and early lettuce (if soil is good). There is still much to be investigated in this field of plant symbiosis and

the home gardener is urged to observe and note down his observations in this connection.

The value of companion cropping now becomes clear. Above the soil as well as under it, neighboring plants supplement one another. For example, the upward striving, two-dimensional leek finds enough room near the bushy celeriac or celery plant. Both are potassium lovers and therefore like well-rotted pig manure. The intercropping of various plants is conditioned by their similarity in soil demands and difference in rate of development. Lettuce and kohlrabi, for instance, develop rapidly and can cover the soil until plants which mature later can do this. After the inter-crop is harvested the more slowly maturing plants remain with plenty of room for their development.

Such a permanent ground cover from mixed cultures helps not only to prevent crusting and drying out of the soil, but to hold the weeds in check. Besides it has a marked influence on the quality, flavor and keeping quality of the vegetables thus grown. Tests have shown too, that nutritive value goes hand in hand with flavor and quality.

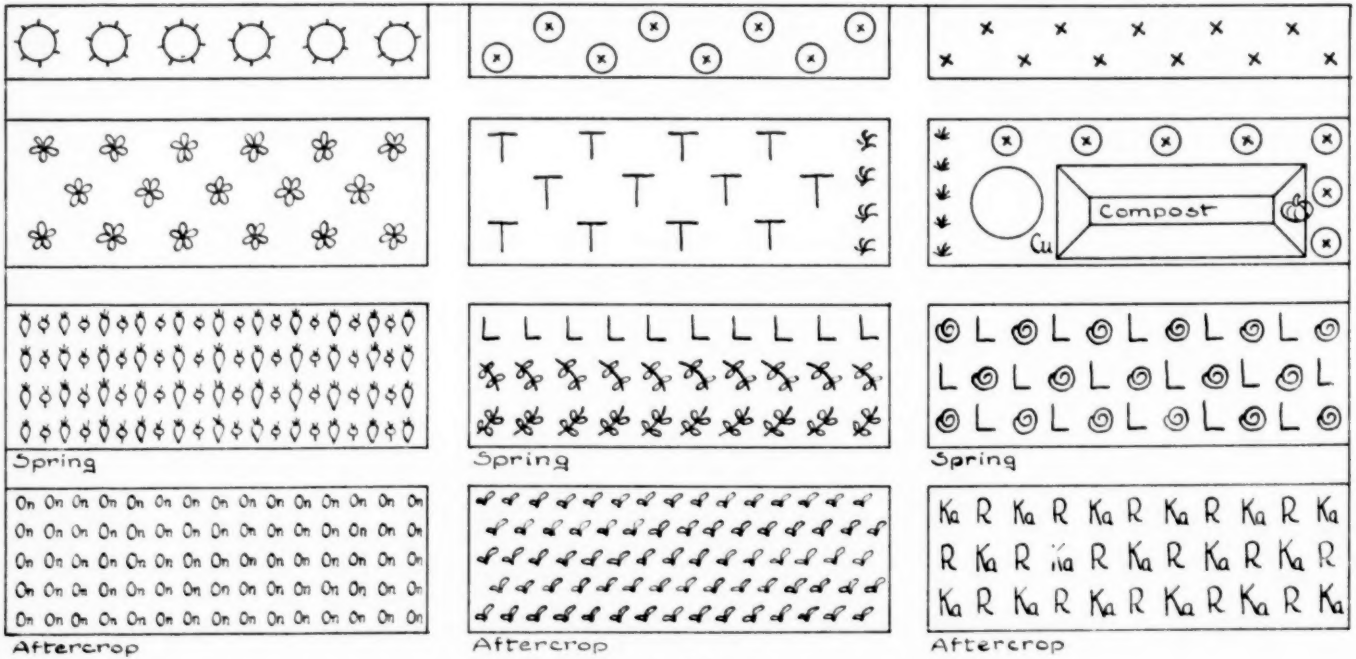
The following simple experiment is a test of companion planting. Make three small plantings of radishes. Border one with garden cress, the second with chervil, and leave the third with no companion plant. You will be able to detect marked differences in the flavor of the radishes. Those grown with chervil are sharp, those with cress are very tasty, those grown alone have less flavor.

The accompanying plans show one way of working out a three year crop rotation in the vegetable garden by using small beds. In the narrower border bed at the top is a rotation of sunflowers, corn and pole beans. The next row of three beds below remains mostly the same each year with strawberry and tomato plantings and the compost pile with its barrel for liquid manure. The two lower rows in each plan show two arrangements of the same three beds, first the early spring planting, later the crop which follows on the same spot.

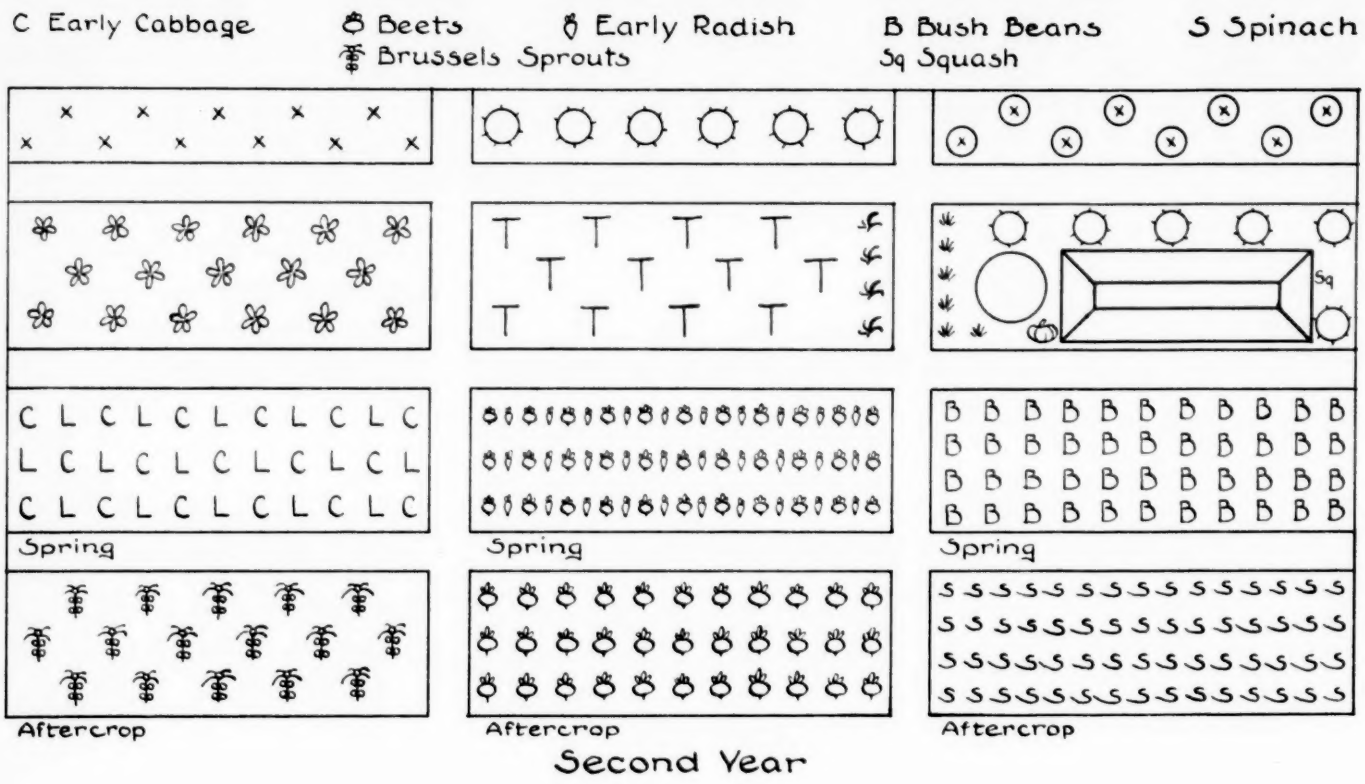
Such a three year crop rotation may be planned just as well with most of the garden in rows instead of beds. The important point is to have a definite plan and to keep it as a record so that heavy feeders are not planted again on the same spot for three years. Likewise the soil improvers need to be moved each year to a new location, and the compost lovers as well.

PLANTING PLANS OF A SECTION OF THE INTENSIVE GARDEN FOR THREE SUCCESSIVE YEARS

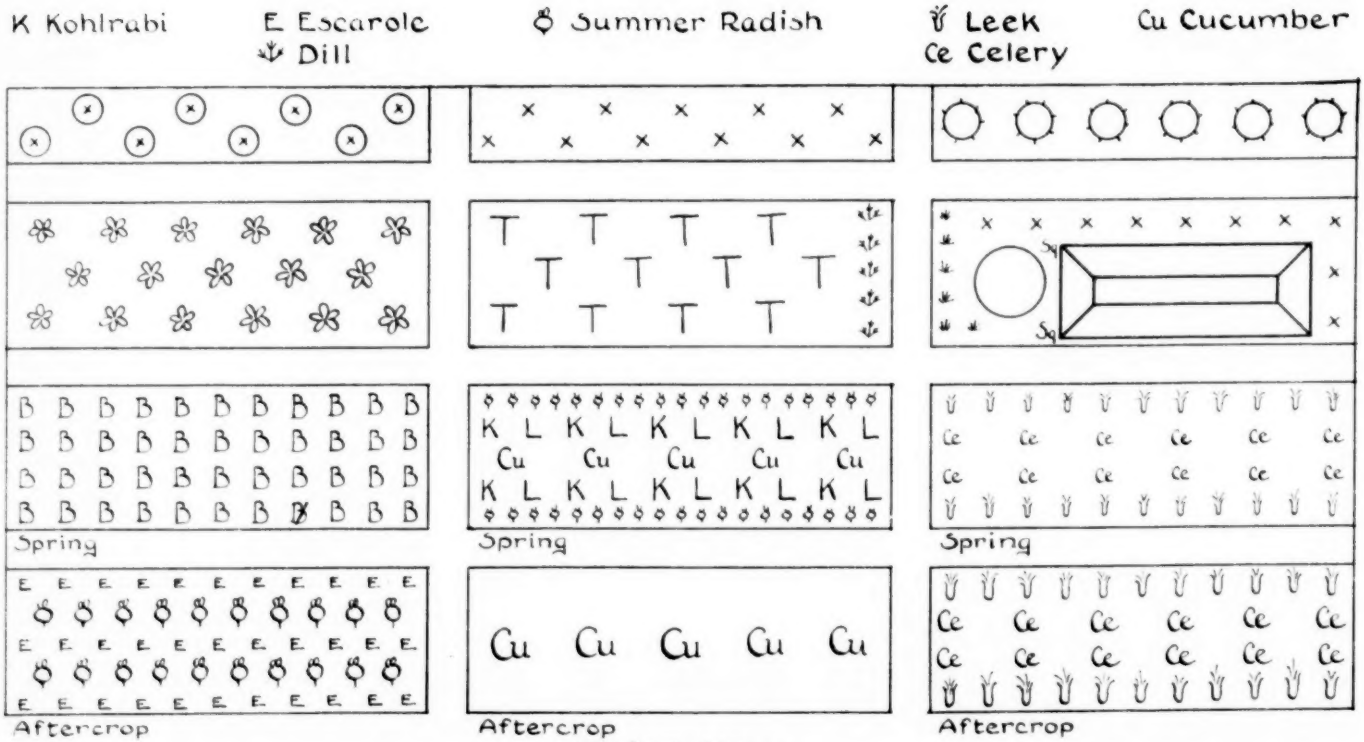
Sunflowers · Pole Beans · Sugar Corn · Strawberries · Tomatoes · Pumpkin · Chives · Parsley · Carrots, Turnips · Red Radish · L Lettuce · Peas · Cauliflower · On Onions · Corn Salad · Ka Kale, Cabbage · R Romaine Lettuce · Cu Cucumber



First Year


C Early Cabbage
Beets
Brussels Sprouts
Early Radish
B Bush Beans
Sq Squash
S Spinach
Sq
Spring
Spring
Spring
Aftercrop
Aftercrop
Aftercrop

Second Year


K Kohlrabi
E Escarole
Dill
Summer Radish
Leek
Ce Celery
Cu Cucumber
Spring
Spring
Spring
Aftercrop
Aftercrop
Aftercrop

Third Year

This rotation of the three kinds of vegetable crops and the right companion plantings combined with the usual bio-dynamic practices of treating manure and compost and of spraying soil and foliage, will help greatly to avoid diseases and pests, to build up the soil equally over the whole garden area and to insure healthy plants and good food.

BEES BELONG IN THE BIO-DYNAMIC PICTURE

STERLING W. EDWARDS

Producing your own honey definitely belongs in the Bio-Dynamic picture. The self-sufficient grower of vegetable foodstuffs also wants to produce his own fruit, fowl, beef, pork, grains and, of course, honey. While not every organic situation today is capable of including a small apiary, nevertheless hundreds of B.D. gardeners and farmers over the country can easily take on some beekeeping. And when they do, they can, if they will, cast off what many people regard as a very pernicious and harmful habit—the use of white sugar.

Now a small apiary like ours requires a little management, some careful attention at times, but is never a burden and, save for the swarming period, can often be left for weeks at a time. Yet the rewards are large, not only in wonderful honey, but the service of the bees as pollinators for your fruit, berries and grains is immeasurable.

Up here in our mountains we look out of bedroom windows down into the carpenter shop chimney; from carpenter shop windows we can see down into the honey house with stacks of drawn comb hive bodies on the floor. All bee activity on this place centers in this building, and keeping bees is just another step along the road to full living for our family. Having two large gardens is another. It may as well be said now that having once lived out of an organic garden, everything that is offered us from the typical fertilized garden—of which there are many in these mountains—seems to have no taste and no quality, for growing things organically has a very subtle effect on a person. All things must taste as good as those from your garden. You want to have everything about you of organic structure, of organic temperament. You want all your friends to be organic enthusiasts too. And you become very much concerned over those

who aren't especially their children. You find yourself telling them that honey would do them more good than all the cheap white sugar they eat.

Many organic gardeners have testified that they will not rest content until everything else they eat is organic as well. Thus, the ever-present question arises: "How can I get this raised organically?" However, while over some items most of us simply cannot exercise any first-hand control, we can search out organic producers of these foods and trust them. Thus while suburban gardeners cannot grow wheat, and northerners cannot produce Bio-Dynamic oranges, yet in both instances these items are to be had from organic producers. In the same way, every organic mind may not beekeep but all will certainly want honey as one of the replacements for sugar.

The honey season in the Blue Ridge Mountains begins with the blooming of the maples, oak and elm in early spring in our section; runs lightly through fruit bloom and berry bloom, and is followed by dandelion, locust, tulip tree, sumac and linden tree bloom. Clovers, when the season is right, yield the most weight of all nectars, while after them comes a resting spell for the bees until goldenrod and fall aster put them to work again. If you talk with beekeepers in your area you can learn what the honey flows are, when they come and what the annual yields average. It is good to make your honey the delightful blend of the nectars of all the flowers from April until October.

The season of 1949 was a good honey year for us. We had 12 hives, of which 8 were strong and 4 weak. We took 400 pounds from the strong ones and left about 80 pounds on each of the colonies as winter stores. Fifty pounds of honey per hive is a low yield as yields go, but it is excellent in these mountains where bee pasture is only middling. Twenty miles away in any direction may yield twice that or even four times our figure. You never can tell what the available bee pasture will produce.

The honey season of 1950 yielded little honey as it was a dry season with not much nectar, but summer of 1951 the total crop was 1233 lbs. from 18 hives, 11 of which were honey producers and 7 just boarded with us for the season. In the past summer of 1952 we took 790 lbs. from 11 hives, of which 7 were good providers, 2 were beginners and the others served as ornaments only.

We make extracted honey as this handles easiest for us, and we strain it through cheesecloth and store it in 60 lb. (5 gal.) cans. We do not heat it nor otherwise handle it. Much of this crop went into our home canning; considerable into cooking and baking. Some honey was constantly on the table; some was traded for needed items, like good organic rye cereal; a little was sold to certain friends who appreciated the highest quality honey.

Honey is not only the sweetening agent par excellence but it has medicinal values as well. You can spend some instructive winter evenings reading a delightful book by Dr. B. F. Beck on *Honey and Your Health*. It should be remembered, too, that honey, like all products of the garden and farm, is not to be *added* to one's diet. Rather, it is to be used *instead* of the many misnamed commercial sweetenings, just as organic products are something to be substituted for the general mass of "store trash" which the present day shopper lugs home from the market. Then you will probably find, as we did, that when you become a steady user of honey, you will no longer desire store candy, soft drinks, commercial ice cream, and other too-sweet sweets. Honey eaters everywhere will confirm this fact.

Yes, keeping bees has become a definite part of our organic way of living, a way which we seem to improve on bit by bit as the months go by. We recommend that you carefully consider beekeeping as a part of your bio-dynamic plan.

Bio-Dynamic Conference 1953

AUGUST FIRST - SECOND - THIRD

If you plan to attend this meeting send your reservations in NOW. Dr. Pfeiffer and other speakers present practical information based on field and laboratory experience, and there are opportunities to hear what others have to say regarding your own farm and garden problems. The conference will be at Threefold Farm, Spring Valley, N. Y. (20 miles from George Washington Bridge). For rates and reservations, write direct to Mrs. E. Kroth at the above address.